Development of a digital data base for power system of Crete, for displaying system's data on geographical maps, using GIS and web tools.

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Abstract: - Geographical Information System (GIS) applications are very helpful tools for displaying and analyzing information for several technological fields. The research group of Electrical Power System Lab (EPSL) of TEIC is developing a GIS software application for displaying the operational conditions of the power system of Crete, presenting also critical information and statistical data for system's characteristics. This job is a part of a project which is co-funded by the European Social Fund and Greek National Resources, "EPEAEK II – ARXIMIDES". This tool is intended to help training of engineers in the Electrical Department of TEIC to simulate and visualize power system operation and characteristics. Besides, this tool is very helpful for a power system engineer in observing the whole system operations and system's data. All data used are derived from a database developed by EPSL. This database includes electrical and operational characteristics such as generating plant, substation, transformers, transmission-distribution lines, cables, wind parks, substation's load and unit's power production recordings etc. Digitalized maps of Crete Island use this data and display them optionally according to user's demand or choice. So, an authorized user can decide which data will be displayed on the map, and with a simple mouse click on a selected element of the map he can b informed about its characteristics. Furthermore, this application is being uploaded on web. This means that this application runs on a server of EPSL,ehich can serve distant users after authorization procedure. That distance user could be a trainee in his desk, o am engineer, or a researcher in the lab. One of the services that this application provide is the load flow calculation on a specific part of the system, or for a specific scenario of system's operation.

Key-Words: - GIS applications, Power Systems observation, power systems web-applications

1. INTRODUCTION

Crete's electrical power system is a large autonomous system with large wind power penetration. The customer's power & energy demand is increasing with high rates. The operation of the whole system is in charge of the Greek PPC (public power corporation) control center, located in Iraklion, where a SCADA system has been installed. In terms of integration of dispersed generation new methods and computer applications are adopted toward adaptation of the critical information of system's operational conditions. Mapping and Geographic Information Systems (GIS) are key to a utility's business. These software applications store and map a vast amount of information about the utility's electric system and other outside plants. People and applications across the organization typically require information from the GIS.

The benefits of adaptation of a GIS for a power system are many. Descriptive presentation of data (graphics, maps, tables etc) and presentation of data in real space are offered. They offer, also, convenience concerning data processing since, as well as to examine them in different layers. It analyzes and presents information related to spatial places. It can combine elements – data from digital data base, GPS for concerning the specific definition of places, sampling and distant measurements. The relation between the data basis and the maps give the chance to the user to interact with the system of an interactive communication between the user and the system. Moreover many data basis can be connected and combined improving the flexibility of the system.

Using specific tools of software design (like map objects) we can display the results of a load flow test on the digital map of Crete.
It's possible to use GIS to define the number of people as well as forecast of load demand. Further more if we know the density (people, space) we can rate the places per load demand.
The amount of data can be presented on maps for a quick estimation of the network-system operational condition.
The GIS can observe external factors such as weather conditions. For example if we know the temperature of an area, we're able to predict the load demand there, for the next hours.
GIS is a helpful tool for new types of energy management.

2. SYSTEM MODELLING - TECHNICAL INFORMATION

2.1 Power Production

The power system of the island of Crete is the largest autonomous power system in Greece with the highest rate of increase nation-wide in energy and power demand. The conventional generation system consists of three major power plants one in Linoperamata, one in Chania and one in Atherinolakos(the latest). The first two power plants are located near the major load points of the island. There are 20 thermal, oil-fired generating units with a total installed capacity of about 742MW. The percentage of the participation of each generator type in the total electrical power production and the annual fuel consumption are depicted in figures 1 and 2(These two figures correspond to the system in 2001, before atherinolakos installation.

The power system comprises the following power stations:

- Six steam turbines in Linoperamata
- Four diesel engines in Linoperamata
- Four gas turbines in Linoperamata & five gas turbines in Chania.
- One combined cycle in Chania of 133.4 MW (2 gas turbines and 1 steam turbine)
- Two diesel engines in Atherinolakos

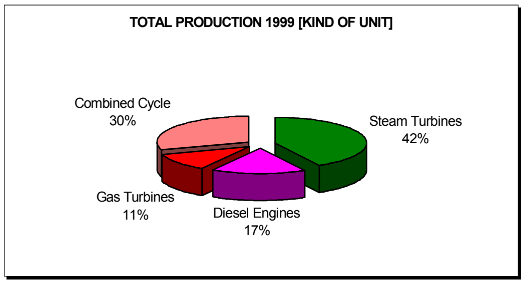

***Figure 1** Oil-fired Units of Crete*

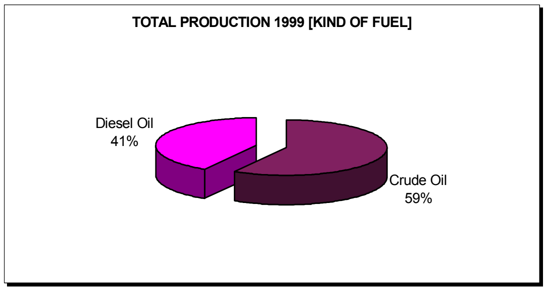

***Figure 2** Oil-fired fuel consumption*

2.2 Load demand

The base load is mainly supplied by the steam and diesel units. The gas turbines normally supply the daily peak load. Until 1988 the annual peak load demand always occurred in winter, from then on it always appears in summer evenings. Figure 3 shows the increase of energy demand and peak load since 1964. One characteristic of the load profile is the large variations (low night valleys – high evening peaks). Gas turbines have a high operating cost that increases significantly the average cost of electricity being supplied.

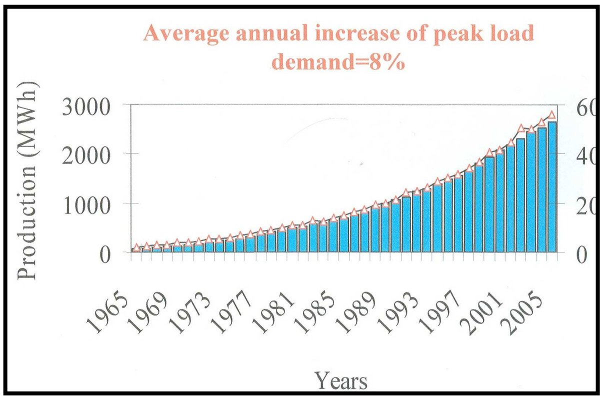

***Figure 3** increase of energy and peak load demand*

2.3 Transmission system

The transmission network (figure 4) consists mainly of 150 kV lines. There are only 2 lines of

66kV from Linop33 (production sub) to 1Irak31 (substation). The distribution network consists of 20 kV (21 kV) and 15 kV (15.75 kV) lines. The generation system and the transmission network are supervised by a control center located in one of the substations_in Iraklio (2IRAK), using a SCADA system.

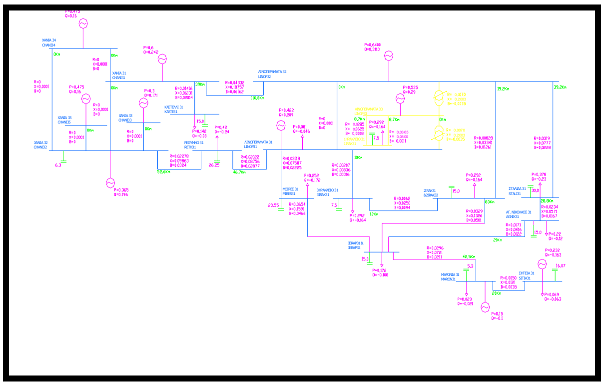

Figure 4 *Single–line drawing of 150kV power system*

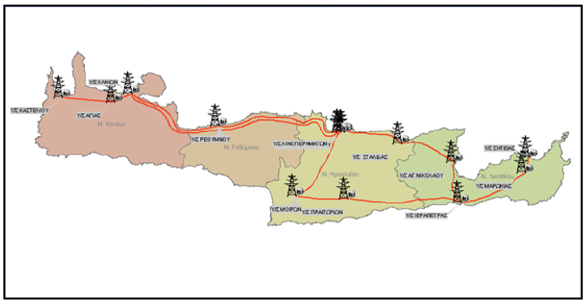

Figure 5 *Single–line drawing of 150kV power system on the map of Crete*

2.4 Wind Parks

About 15 Wind Parks(WPs) have been installed in Crete since 1995 of total capacity of up to 125 MW and there are plans for more WPs in the next years. The peak wind penetration was up to 41.2%. Most of the wind parks have been installed at the eastern part of the island (Sitia) that presents the most favourable wind conditions. As a result, in case of faults on some particular lines, the majority of the wind parks will be disconnected.

Furthermore, the protections of the WPs might be activated in case of frequency variations, decreasing additionally the dynamic stability of the system. Extensive transient analysis studies have therefore been conducted in order to assess the dynamic behaviour of the system under various disturbances and with different combinations of the generating units.

2.5 Technical constraints

The start up preparation time of a generator depends on its type. The gas turbines require 6-12 minutes for preparation. The steam turbines require 1-2 hours in 'hot' state, and 8 or more hours for the 'cold' state. The diesels require about 20 minutes. In addition, the increase rate of power of each generator also depends on its type. For the steam turbines is low. For the gas turbines it is 16-17 MW/min. Diesel' s rate is also high, as they react rapidly to load variations. In order to avoid undesirable frequency increase, the generator is at its technical minimum when it is connected to the system.One of the biggest problems of the system is the high fuel cost. Gas turbines consume diesel oil which is expensive and increases the energy cost per KWh. Steam turbines and diesel engines consume crude oil. (diesel engines consume diesel oil only at the start up state and the stop state) Diesel engines, steam turbines and wind parks reduce the cost per KWh.

3. Creation of GIS

The first part of this project was the creation of GIS maps that represent the Electrical Power System of Crete. For this reason we created a Geographical Information System (GIS) using ArcGIS and Microsoft Access. Using ArcGIS and Microsoft Access we represented substations, transmission lines, renewable sources, power plants of Crete presented over a digitized map.

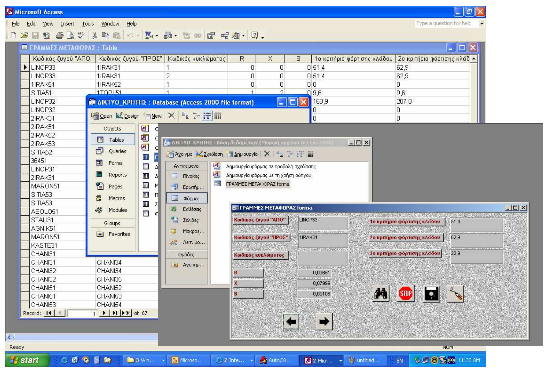

Figure 6 *– The access data base for Crete power system*

For every substation the elements that were imported in the database and can be viewed on the map are:

1. Name of the substation
2. Number of busses
3. Type of the substation
4. Transformer data
5. Capacitor banks
6. Load Demand data

For the transmission lines the elements that were imported in the database and can be viewed on the map are:

1. Circuit type
2. Circuit length
3. electrical data such as R,X,B
4. 1^{st},2^{nd} and 3^{rd} loading limits

For the renewable sources and the power plants the elements that were imported in the database were:

1. location
2. Installed Power
3. Electrical data

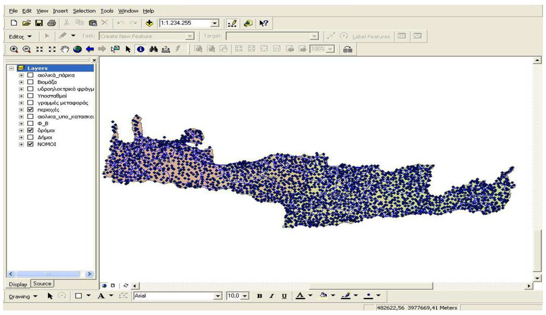

Figure 7 *– Layers on GIS*

4. Web part

On the second part of this project our aim was to transform the digitized maps that were created with the use of ARCGIS in a format that can be viewed in Web. For this reason we used technologies such as Apache, MySQl and SVG (Scalable Vector Graphics).
We developed a Web server on a Linux SuSe 10.0 Server where Apache Web Server was installed.
The second step was to import the database that was analyzed in step 1 from windows access to MySQL. The choice for MySQL was based on the fact that is a database capable to work on Web environment(figure 11).
The third step was the transformation of GIS maps in a format that can be viewed in Web

Figure 8 *– Detailed Geographical data for Wind Park*

After the completion of the first part of the project, the result was the creation of digitalized maps of Crete where the user can work with, using programs such as ArcGIS or other similar programs. One simple program which presents system's data is cmd01(fig.9). It has been developed by EPSL using ESRI's map objects. The user chooses the layers (data) he wants to be displayed on the map of Crete. He can also zoom in or zoom out in order to observe the desired area of the network.

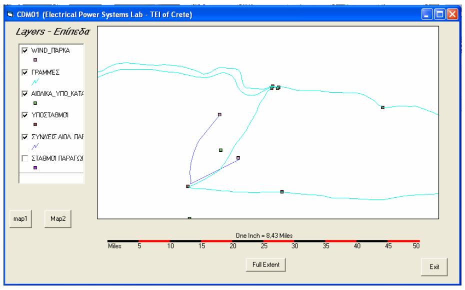

Figure 9 *– The cmd01 GIS application*
(Based on map objects)

explorers. Our choice was by default SVG. SVG is a platform for two-dimensional graphics. It has two parts: an XML-based file format and a programming API for graphical applications. Key features include shapes, text and embedded raster graphics, with many different painting styles. It supports scripting through languages such as ECMAScript and has comprehensive support for animation.
SVG is used in many business areas including Web graphics, animation, user interfaces, graphics interchange, print and hardcopy output, mobile applications and high-quality design.
SVG is a royalty-free vendor-neutral open standard developed under the W3C Process. It has strong industry support; Authors of the SVG specification include Adobe, Agfa, Apple, Canon, Corel, Ericsson, HP, IBM, Kodak, Macromedia,

Microsoft, Nokia, Sharp and Sun Microsystems. SVG viewers are deployed to over 100 million desktops, and there is a broad range of support in many authoring tools.
SVG builds upon many other successful standards such as XML (SVG graphics are text-based and thus easy to create), JPEG and PNG for image formats, DOM for scripting and interactivity, SMIL for animation and CSS for styling.

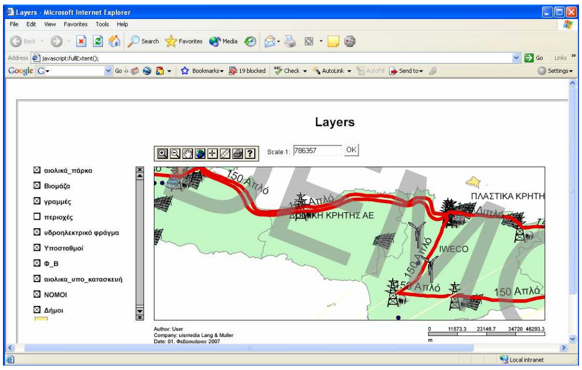

Figure 10 *– The GIS web-application for power system of Crete on a web browser (Internet Explorer)*

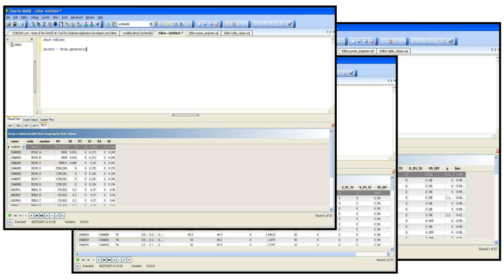

Figure 11 *– MySQL data base for Power System Of Crete*

5. Load flow analysis

The Last part of the project is the creation a Load Flow Analysis of the network where the user can interact with the SVG map and perform a Load flow Analysis of the power system of Crete. This application is under construction and it will be accomplished till May 2007. The Gauss-Seidel Algorithm is used and it has been performed on a simplified 9-buses model of the network.
An authorized distant user will be able to input in a appropriate form the load demand (P(MW) and Q(MVar)) data for the 9 specific high voltage buses (High Voltage/Low Voltage Substations) and generators' production. The server will execute the Gauss-Seidel load flow calculations. SVG is interoperable. The W3C release a test suite and implementation results to ensure conformance.
The tool that was used to transform the GIS maps to SVG format was the MapViewSVG from UisMedia. The result was the creation of digitized maps of the Power System of Crete were a user using a Web explorer such as IE of Firefox can interact with the map and decide which parts of the Power System to be shown (Power Plants, substations etc).
Results will be displayed on web, on the specific elements (substations) of the map of Crete.
The realization of the algorithm is going to be constructed using PHP and Jscript that will use the data elements of the Mysql database described above.

6. Conclusions

GIS applications are very helpful in displaying a variety of data for power systems' characteristics and operation. EPSL has developed a database and a GIS tool for the power system of Crete. This work has been uploaded on web. Students of Electrical Department of TEI of Crete can be training on power systems' operation and can observe systems' electrical characteristics. There is a complete model of a real autonomous power system on web, featuring all related data such as transmission lines, generators, capacitors etc. Besides an authorized user can apply changes to the model in case of changes of the power system (for example new capacitors, transmission lines, substations etc).
The above mentioned system will be capable to support load flow analysis based on real data of the Crete Power System. For the end user(for example a student) there will be the capability to accomplish that Load Flow Analysis without the need to use specialized software.

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